AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently Amended) A laser comprising:

a laser medium comprising $H_2(1/p)$ where p is an integer and $1 \leq p \leq 137$,

a cavity comprising the laser medium, and

a power source to form an inverted population in the energy level of $H_2(1/p)$; wherein the power source forms excited vibration-rotational levels of $H_2(1/p)$ and lasing occurs with a stimulated transition from at least one vibration-rotational level to at least another lower-energy-level other than one with a significant Boltzmann population at the cell neutral-gas temperature wherein the vibration-rotational levels of $H_2(1/p)$ comprise the inverted population.

2. (Original) The laser of claim 1 further comprising cavity mirrors and a laser-beam output.

3. (Cancelled)

4. (Previously Presented) The laser of claim 1 wherein the laser light is within the range of wavelengths of at least one of infrared, visible, ultraviolet, extreme ultraviolet, and soft X-ray.

5. (Previously Presented) The laser of claim 1 wherein the laser medium further comprises an activator molecule.

6. (Previously Presented) The laser of claim 5 wherein the activator molecule is chosen from O_2, N_2, CO_2, CO, NO_2, NO, and XX' where each of X and X' is a halogen atom that may be the same or different.

5. (Duplicative - Cancelled)

6. (Duplicative - Cancelled)

7. (Previously Presented) The laser of claim 150 further comprising a particle beam.

8. (Original) The laser of claim 7 wherein the particle beam is an electron beam.

9. (Previously Presented) The laser of claim 150 wherein the power source accelerates the energetic particle.

10. (Previously Presented) The laser of claim 9 wherein the power source is chosen from at least one of a particle beam, microwave, high voltage, and RF discharges.

11. (Previously Presented) The laser of claim 5 further comprising a means to energetically excite the activator molecule comprising at least one of a particle beam, microwave, glow, and RF discharge power.

12. (Previously Presented) The laser of claim 1 wherein the power source comprises a particle beam.

13. (Previously Presented) The laser of claim 12 wherein the particle beam energy ranges from 0.1 to 100 MeV.

14. (Previously Presented) The laser of claim 12 wherein the particle beam current ranges from 0.01 μA to 1000 A.

15. (Currently Amended) The laser of claim [[~~3~~]] <u>1</u> wherein the vibrational energies are given by

$$E_{vib} = p^2 0.515902\ eV$$

and the rotational energies are given by

$$E_{rot} = E_{J+1} - E_J = \frac{\hbar^2}{I}[J+1] = p^2(J+1)0.01509\ eV$$

within at least one of about ±20%, ±10%, and ±5% where p is an integer greater than one and J is an integer.

16. (Currently Amended) The laser of claim [[~~3~~]] <u>1</u> where the energies of the emission are given by

$$E_{vib-rot} = p^2 E_{vib\,\upsilon} \pm p^2(J+1)E_{rot\,H_2}$$

wherein

$$E_{vib\,\upsilon} = \upsilon p^2 0.5159\ eV$$

$$-\upsilon(\upsilon-1)\left(1.23981\ X\ 10^{-4}\right)\frac{100hc\left(8.06573X10^3\ \frac{cm^{-1}}{eV}\,p^2 0.5159\ eV\right)^2}{4e\left(p^2 4.151\ eV + p^3 0.326469\ eV\right)}\ eV$$

and the rotational energies are given by

$$E_{rot} = E_{J+1} - E_J = \frac{\hbar^2}{I}[J+1] = p^2(J+1)0.01509\ eV$$

within at least one of about ±20%, ±10%, and ±5% where ν = 0, 1,2, 3... integer, p is an integer greater than one, and J is an integer.

17. (Previously Presented) The laser of claim 1 wherein the medium comprises at least one of H_2 (1/12), H_2 (1/13), and H_2 (1/14).

18. (Previously Presented) The laser of claim 17 wherein the wavelength of laser light ranges from 5-20 nm.

19. (Previously Presented) The laser of claim 2, wherein the mirrors comprise multilayer, thin film coatings.

20. (Original) The laser of claim 19 wherein the wavelength is at least one of about 13.4 nm and 11.3 nm and the mirrors comprise Mo:Si ML.

21. (Previously Presented) The laser of claim 2, wherein the exit for the beam output comprises an ultraviolet transparent window.

22. (Previously Presented) The laser of claim 2, wherein the beam output comprises a differentially pumped pin-hole optic.

23. (Previously Presented) The laser of claim 8 wherein the cavity further comprises an electron window.

24. (Cancelled)

25. (Withdrawn) A laser comprising:

a plasma forming cell or reactor for the catalysis of atomic hydrogen producing power, a continuous stationary inverted $H_2(1/p)$ population where p is an integer and $1 < p < 137$, and novel hydrogen species and compositions of matter comprising new forms of hydrogen,

a source of catalyst,

a source of atomic hydrogen, and

means to form and output a laser beam.

26. (Withdrawn) The laser of claim 25 wherein the cell is capable of maintaining a vacuum or pressures greater than atmospheric pressure.

27. (Withdrawn) The laser of claim 25 wherein the catalysis of atomic hydrogen generates a plasma, power, and novel hydrogen species and compositions of matter comprising new forms of hydrogen.

28. (Withdrawn) The laser of claim 25 wherein the means to form and output a laser beam comprises a cavity, cavity mirrors, and a beam output.

29. (Withdrawn) The laser of claim 28 wherein the cavity comprises a reactor to catalyze atomic hydrogen to lower-energy states, and the reactor is chosen from an rt-plasma reactor, a plasma electrolysis reactor, a barrier electrode reactor, an RF plasma reactor, a pressurized gas energy reactor, a gas discharge energy reactor, a microwave cell energy reactor, a combination of a glow discharge cell and a microwave reactor, a combination of a glow discharge cell and~~/or~~ an RF plasma reactor, and an electron-beam plasma reactor.

30. (Withdrawn) The laser of claim 25 wherein the reactor comprises a source of hydrogen; one of a solid, molten, liquid, and gaseous source of catalyst; a vessel comprising hydrogen and the catalyst wherein the reaction to form lower-energy hydrogen occurs by contact of the hydrogen with the catalyst; and a means for providing

the lower-energy hydrogen product $H_2(1/p)$ to the laser cavity to comprise the laser medium.

31. (Previously Presented) The laser of claim 1, wherein the laser medium comprises a plasma maintained by a particle beam, and wherein the cavity comprises a reactor to catalyze atomic hydrogen to lower-energy states.

32. (Withdrawn) The laser of claim 25 wherein the plasma provides atomic hydrogen, or the cell further comprises a dissociator such as a filament, or metal such as platinum, palladium, titanium, or nickel that forms atomic hydrogen from the source of atomic hydrogen.

33. (Withdrawn) The laser of claim 25 where the source of catalyst is an excimer.

34. (Withdrawn) The laser of claim 33 wherein the excimer is at least one of chosen from He_2^*, $Ne_2{}^*$, $Ne_2{}^*$, and Ar_2^*, and the catalyst is chosen from He^+, Ne^+, Ne^+/H^+ and Ar^+.

35. (Withdrawn) The laser of claim 33 wherein the excimer is formed by a high pressure discharge.

36. (Withdrawn) The laser of claim 35 wherein the discharge is one of a microwave, glow, RF, and electron-beam discharge.

37. (Withdrawn) The laser of claim 25 comprising a noble-gas-catalyst source-hydrogen mixture which is maintained at high pressure in the range of about 100 mTorr to 100 atm.

38. (Withdrawn) The laser of claim 25 further comprising a source of ionization to form the catalyst from the source of catalyst.

39. (Withdrawn) The laser of claim 38 wherein the source of ionization to form the catalyst from the source of catalyst is at least one of an electron beam and an ionizing species.

40. (Withdrawn) The laser of claim 39 wherein the ionizing species comprises an ion.

41. (Withdrawn) The laser of claim 39 wherein the ionizing species reacts with a source of catalyst comprising a noble gas excimer to form the catalyst.

42. (Withdrawn) The laser of claim 41 wherein the source of catalyst is Ar_2*, the ionizing species is O^+ which reacts to form the catalyst according to the reaction:

$$Ar_2{}^* + O^+ \rightarrow Ar + Ar^+ + O$$

43. (Withdrawn) The laser of claim 25 wherein the catalysis of hydrogen is maintained by a particle beam, microwave, glow, or RF discharge plasma of a source of atomic hydrogen and a source of catalyst.

44. (Withdrawn) The laser of claim 39 wherein a species reacts with the source of catalyst to form the catalyst.

45. (Previously Presented) The laser of claim 1 wherein the $H_2(1/p)$ pressure is maintained in the range of about 0.1 mTorr to 10,000 Torr.

46. (Previously Presented) The laser of claim 1, wherein the $H_2(1/p)$ flow rate ranges from about 0-1 standard liters per minute per cm^3 of vessel volume.

47. (Previously Presented) The laser of claim 1, wherein the power density of the source of power ranges from about 0.01 W to about 100 W/cm^3 vessel volume.

48. (Previously Presented) The laser of claim 5 wherein the activator molecule comprises a gas having a mole fraction of 0.001% to 90.

49. (Original) The laser of claim 1 further comprising a catalyst cell, a catalyst, and a source of hydrogen to catalyze the formation of hydrogen to lower-energy states.

50. (Withdrawn) The laser of claim 25 where the pumping power to form the inverted population is from at least one of the external power supply and the power released from the catalysis of atomic hydrogen to lower-energy states.

51. (Original) The laser of claim 6 wherein energetic particles are formed by the catalysis of atomic hydrogen.

52. (Original) The laser of claim 6 wherein the pumping excitation for the formation of the inverted population or the excitation of the activator is due to collisions with energetic particles formed by the catalysis of atomic hydrogen.

53. (Original) The laser of claim 1 comprising a source of $H_2(1/p)$.

54. (Withdrawn) The laser of claim 25 wherein $H_2(1/p)$ is generated insitu from the catalysis of hydrogen to lower-energy states given by

$$E_n = -\frac{e^2}{n^2 8\pi\varepsilon_o a_H} = -\frac{13.598\ eV}{n^2}$$
$$n = \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \ldots, \frac{1}{p}; \quad p \leq 137$$

which further react to form $H_2(1/p)$.

55. (Withdrawn) The laser of claim 25 wherein the catalysis cell is also the laser cavity.

56. (Withdrawn) The laser of claim 25 wherein the reactor comprises a source of hydrogen; one of a solid, molten, liquid, and gaseous source of catalyst; a vessel containing hydrogen and the catalyst wherein the reaction to form lower-energy hydrogen occurs by contact of the hydrogen with the catalyst; and a means for providing the lower-energy hydrogen product $H_2(1/p)$ to the laser cavity to comprise the laser medium.

57. (Withdrawn) The laser of claim 25 wherein the formation of the inverted population is due to at least one of input power and catalysis of atomic hydrogen to lower-energy states, $H_2(1/p)$ is formed insitu due to the catalysis of atomic hydrogen, the catalysis cell serves as the laser cavity, and an inverted population may be formed due to at least one of catalysis of atomic hydrogen and input power.

58. (Original) The laser of claim 1 further comprising a catalyst-hydrogen mixture to achieve at least one of the formation of $H_2(1/p)$ and the formation of an inverted vibration-rotational population of $H_2(1/p)$.

59. (Withdrawn) The laser of claim 25 wherein the pressure of a mixture of a source of catalyst and atomic hydrogen source is maintained in the range of about 0.1 mTorr to 10,000 Torr.

60. (Withdrawn) The laser of claim 25 wherein the flow rate of the mixture of a source of catalyst and atomic hydrogen source ranges from about 0-1 standard liters per minute per cm^3 of vessel.

61. (Withdrawn) The laser of claim 1 or 25 wherein the power density of the source of pumping power ranges from about 0.01 W to about 100 W/cm^3 vessel volume.

62. (Withdrawn) The laser of claim 25 wherein the mole fraction of hydrogen in the catalyst-hydrogen gas ranges from 0.001% to 90%.

63. (Withdrawn) The laser of claim 62 wherein, the flow rate and pressure are maintained according to that of catalyst- hydrogen mixture to achieve the desired mole fraction.

64. (Withdrawn) The laser of claim 25 wherein the source of catalyst is chosen from helium, neon, and argon, and the catalyst is chosen from He^+, Ne^+, Ne^+/H^+ and Ar^+.

65. (Withdrawn) A laser comprising a laser cavity, cavity mirrors, a source of applied power to maintain a hydrogen catalysis reaction, an internal power source comprising a cell for the catalysis of atomic hydrogen to form novel hydrogen species and/or compositions of matter comprising new forms of hydrogen, wherein at least one of the power from catalysis and an external power source maintains $H_2(1/p)$ in an excited vibration-rotational state from which stimulated emission occurs.

66. (Previously Presented) A light source comprising:

a light-emitting medium comprising $H_2(1/p)$ where p is an integer and $1 < p \leq 137$,

a cavity comprising the light-emitting medium, and

a power source to produce and maintain the energy level of $H_2(1/p)$ for emission of light.

67-73. (Cancelled)

74. (Withdrawn) The laser of claim 1, further comprising a catalyst comprising a chemical or physical process that provides a net enthalpy of $m \cdot 27.2 \pm 0.5$ eV where in m is an integer or $m/2 \cdot 27.2 \pm 0.5$ eV where m is an integer greater than one.

75. (Withdrawn) The laser of claim 74, wherein said catalyst provides a net enthalpy of $m \cdot 27.2 \pm 0.5$ eV where m is an integer or $m/2 \cdot 27.2 \pm 0.5$ eV where m is an integer greater than one corresponding to a resonant state energy level of the catalyst that is excited to provide the enthalpy.

76. (Withdrawn) The laser of claim 74, wherein said catalyst comprises a catalytic system provided by the ionization of t electrons from a participating species such as an atom, an ion, a molecule, and an ionic or molecular compound to a continuum energy level such that the sum of the ionization energies of the t electrons is approximately $m \cdot 27.2 \pm 0.5$ eV where m is an integer or $m/2 \cdot 27.2 \pm 0.5$ eV where m is an integer greater than one and t is an integer.

77. (Withdrawn) The laser of claim 74, wherein the catalyst is provided by the transfer of t electrons between participating ions; the transfer of t electrons from one ion to another ion provides a net enthalpy of reaction whereby the sum of the ionization energy of the electron donating ion minus the ionization energy of the electron accepting ion equals approximately $m \cdot 27.2 \pm 0.5$ eV where m is an integer or $m/2 \cdot 27.2 \pm 0.5$ eV where m is an integer greater than one and t is an integer.

78. (Withdrawn) The laser of claim 74, wherein m is an integer less than 400.

79. (Withdrawn) The laser of claim 74, said catalyst comprising He+ which absorbs 40.8 eV during the transition from the n = 1 energy level to the n = 2 energy level which corresponds to 3/2·27.2 eV (m=3) that serves as a catalyst for the transition of atomic hydrogen from the n = 1 (p = 1) state to the n = 1/2 (p = 2) state.

80. (Withdrawn) The laser of claim 74, said catalyst comprising Ar^{2+} which absorbs 40.8 eV and is ionized to Ar^{3+} which corresponds to 3/2·27.2 eV (m = 3) during the transition of atomic hydrogen from the n = 1 (p = 1) energy level to the n = 1/2 (p = 2) energy level.

81. (Withdrawn) The laser of claim 74, said catalyst comprising at least one of Li, Be, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Kr, Rb, Sr, Nb, Mo, Pd, Sn, Te, Cs, Ce, Pr, Sm, Gd, Dy, Pb, Pt, He^{+}, Na^{+}, Rb^{+}, Sr^{+}, Fe^{3+}, Mo^{2+}, Mo^{4+}, and In^{3+}.

82. (Withdrawn) A laser of claim 74, wherein said catalyst is capable of providing a net enthalpy of $m \cdot 27.2 \pm 0.5$ eV where m is an integer or $m/2 \cdot 27.2 \pm 0.5$ eV where m is an integer greater than one, and capable of forming a hydrogen atom having a binding energy of about $\frac{13.6eV}{\left(\frac{1}{p}\right)^2}$ where p is an integer wherein the net enthalpy is provided by the breaking of a molecular bond of the catalyst and the ionization of t electrons from an atom of the broken molecule each to a continuum energy level such that the sum of the bond energy and the ionization energies of the t electrons is approximately $m \cdot 27.2 \pm 0.5$ eV where m is an integer or $m/2 \cdot 27.2 \pm 0.5$ eV where m is an integer greater than one.

83. (Withdrawn) The laser of claim 82 wherein the catalyst comprises at least one of C_2, N_2, O_2, CO_2, NO_2, and NO_3.

84. (Previously Presented) The laser of claim 1, further comprising a catalyst comprising a molecule in combination with an ion or atom.

85. (Previously Presented) The laser of claim 84, wherein the catalyst comprises at least one molecule chosen from C_2, N_2, O_2, CO_2, NO_2, and NO_3 in combination with at least one atom or ion chosen from Li, Be, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Kr, Rb, Sr, Nb, Mo, Pd, Sn, Te, Cs, Ce, Pr, Sm, Gd, Dy, Pb, Pt, Kr, He^+, Na^+, Rb^+, Sr^+, Fe_3^+, Mo_2^+, Mo_4^+, In_3^+, He^+, Ar^+, Xe^+, Ar_2^+, Ne^+, and H^+.

86-103. (Cancelled)

104. (Withdrawn) A laser comprising:

a plasma forming cell or reactor for the catalysis of atomic hydrogen producing power,

a continuous stationary inverted $H_2(1/p)$ population where p is an integer and $1 < p \leq 137$, and novel hydrogen species and compositions of matter comprising new forms of hydrogen,

a source of catalyst,

a source of atomic hydrogen,

a controller to cause atomic hydrogen to react with atomic hydrogen to form lower-energy states given by

$E_n = -\frac{e^2}{n^2 8\pi\varepsilon_0 a_H} = -\frac{13.598eV}{n^2}$ and $H_2(1/p)$

$n = \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, ..., \frac{1}{p}$; $p \leq 137$, and

a means to form and output a laser beam.

105 -137. (Cancelled)

138. (Withdrawn) A laser comprising:

a plasma forming cell or reactor for the catalysis of atomic hydrogen producing power, a continuous stationary inverted population with energy levels given by $p^2(0.515 \pm 0.151)$ eV where *p* is an integer and novel hydrogen species and compositions of matter comprising hydrogen,

a source of catalyst,

a source of atomic hydrogen,

a controller to cause atomic hydrogen to react with atomic hydrogen to cause EUV emission lines with energies of $q \cdot 13.6$ eV where *q* is an integer, and

a means to form and output a laser beam.

139. (Withdrawn) The laser of claim 25 further comprising a means to provide water vapor to the plasma and a means to remove hydrogen and oxygen dissociated from the water vapor by the plasma such that the gases are collected as industrial gases.

140. (Withdrawn) The laser of claim 25 further comprising an electron beam from a gun wherein the beam energy is tunable and the free electrons serve as the catalyst wherein the free electrons undergo an inelastic scattering reaction with hydrogen atoms.

Claims 141-148. (Cancelled)

149. (Currently Amended) The laser of claim [[~~3~~]] 1 wherein the vibration-rotational excitation occurs by at least one of a direct collisional excitation and an energy exchange with an excited state species.

150. (Previously Presented) The laser of claim 5 wherein at least one of the direct excitation and the excitation of the activator occurs by collision with an energetic particle.